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Review of Renewable Energies, Technology, Economics Aspects and Potentials for Replacing Other Energy Sources

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ABSTRACT
These days, energy rules global economic activities and is considered as an input for almost every products and services. Fossil fuels, including coal, oil and natural gas, are currently the world's primary energy source. Increasing the total population of the world, improving the standards of living, and changing the people's life style causes the total demand for energy to rise significantly so new sources of energy are needed. This paper review different renewable energy resources and provide brief economics and mathematical support for each category.
Keywords: Energy; Renewable Energy, Fossil Fuel, Financial Development

I. INTRODUCTION

These days, energy rules global economic activities, the world depends strongly on natural gas, coal, and oil to provide enough energy for its actions. Energy is considered as an input to almost every product and service in the economy. Energy sectors around the world contribute to the economic activities in two different ways. The first way is that energy is a critical economic sector which produces jobs and value by extracting, relocating, and distributing energy goods and services throughout the economy. The second way is that the energy sector's imp act ripples through the rest of the economy.

Increasing the total population of the world, improving the standards of living, and changing the people's life style causes the total demand for energy to rise significantly. According to International Renewable Energy Agency (IRENA,2015), total demand for energy is expected to rise 21% by 2030. Providing these amounts of energy has a critical impact on our environment and our daily life. These sources of energy are not renewable which makes them not last forever. with passing time, their supplies will be limited and difficult to retrieve so their prices will increase significantly. One of the big concerns of government is about the climate change which motivates them to find ways worldwide to supply energy while minimizing greenhouse gas emissions and other environmental impacts. It should be mentioned that any sort of decisions which are made by the government regarding the investment in the energy sectors have a strong influence on the whole economy over the following decades, and the energy sector influences the vibrancy and sustainability of the total economy. Furthermore, the intersection between economic perspective, technology, and energy management engenders a significant knowledge which results in productivity for energy system. Sort of These decisions regarding the investment in energy sectors, changing the infrastructure systems can have direct or indirect influences on the financial development of the country. According to Çiftçioğlu and Almasifard (2015), different levels of financial development in a certain country influence people's decision regarding their saving or consumption [7][22], so we can argue that macro-level decisions regarding energy sectors show impact in decisions made by individuals in that countries. Providing more cost effective, reliable, and environmentally sustainable energy has a direct relation with long-term stable economic growth. Moreover, long-term stability of energy supplies along with the integrity of suppliers and buyers results in more customer satisfaction and cost reduction (Khorasani, 2014) [14]. More reliable and broader access to energy and less adverse climate change impacts can be listed as reasons for the increased popularity of renewable energy in recent decades. Government and policy makers are interested in the potential benefits of renewable energy expansion on economic growth and job creation. IRENA (2015) estimated that the

renewable energy sectors all around the world hired approximately 9.2 million people.

Due to the reasons mentioned above, using renewable energy has tremendous benefits for us and I believe renewable energy is the best replacement for the energy that comes from fossil fuels, so I would discuss using Renewable energy for generating energy.Natural and renewable energy sources can generate green electricity which is categorized as less harmful sources of energy for the environment. The energy produced by new sources such as solar, water, wind, rain and wave can be called renewable energy because unlike the old resources like fossil fuel or gas they will not be extinguished. According to the recent study, "between 2005 and 2030 world primary energy is expected to grow at an average annual growth rate of 1.8%"[10].
There is a direct relation between the amount of fossil fuel which we use and the amount of carbon monoxide which exists. As we know these carbon dioxides will cause global warming. These days we hear a lot about global warming which can be named as the main reason for climate changes, so it is important for us to change our consumption behavior of traditional sources of energy and try to use renewable energy as much as possible or even find a way to reduce the amount of carbon monoxide from our environment which will be so helpful for protecting the environment. Currently developed and developing countries invest a lot in renewable energy to reduce dependency on oil and gas. They use advanced technology to get renewable energy such as wind power, hydropower, geothermal energy, solar energy, and bioenergy. In the following sectors, different sources of renewable energy will be presented. In each section, a short definition, economic aspects will be provided.

II. RENEWABLE ENERGY

Wind Power

There are two main wind turbine designs (Valentine 2014)- horizontal axis (HAWT) and vertical axis. The vertical axis (VAWT), generally are not used to generate electricity. The main part of the wind turbine includes the rotor blade. On the upon the tower, and also the control system and transformer is usually placed on the base of the tower. Most of the new wind turbines use three blade rotors, to compare two blade rotor they are more resilient. The amount of collected energy is related to the swept area of the wind turbine. One of the biggest challenges for engineering is to produce proper bigger blade rotor regarding rotation friction. In 1985 the wind turbine with 15m diameter could produce 500kw. In June 2013, they increased the diameter size to 164m, and the new wind turbine can generate 8 MW. The area that V164 - 8MW can sweep is three times bigger than football pitches. If we assume the efficiency equal to 0.4 and average speed equal to 7 km/h follow themacr below formula we can get 500 KW.

$$P_{avail} = \frac{1}{2}\rho A V^3 C_p \quad (1)$$

$$p = \frac{1}{2}\times 1.23\times 15^2\times\pi\times 7^2\times 12^3\times 0.4 \approx 500KW \quad (2)$$

Also for 164 m diameter we have:

$$p = \frac{1}{2}\times 1.23\times 164^2\times\pi\times 7^2\times 12^3\times 0.4 \approx 8MW \quad (3)$$

Figure 1 indicates the relation between size and power generation in a wind turbine.

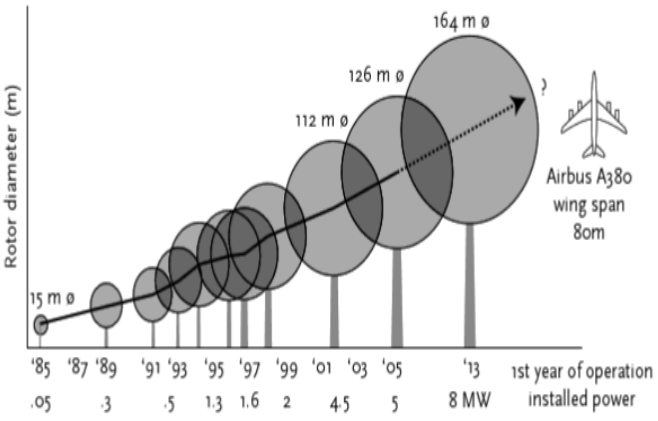

Figure1: Wind Turbine

A. Colinear Wind Turbines (HAWT)

There are two different kinds of horizontal axis turbine: high speed with narrow blades of asymmetrical aerodynamic profile and the low speed with a large number of rather wide blades. For reducing a loading in a storm situation some of Wind Turbines have shutters. the high speed is suitable for electric power generation and the low speed is used in some mechanical devices such as the wind and water mills. Figure 2 shows the picture of the high-speed and low-speed wind turbine.

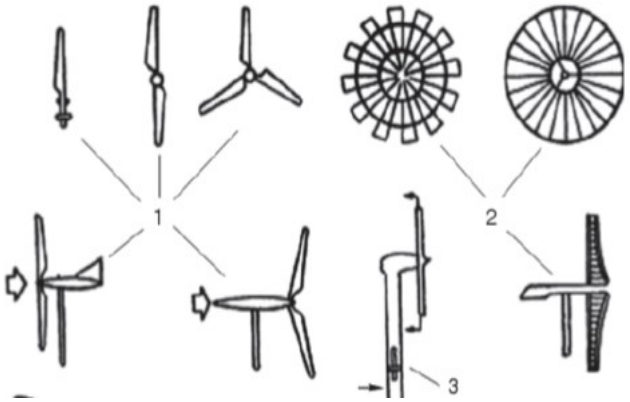

Figure 2: High Speed and Low Speed Turbine

B. Mathematic Model of Wind Turbine

Under constant acceleration, the kinetic energy is equal to work done, W, in displacing the object from rest to distances under force F.
We have:

$$E = W = F_s \tag{4}$$

based on Newton`s law:

$$F = Ma \tag{5}$$

so

$$E = mas \tag{6}$$

using the equation of motion, we have:

$$V^2 = U^2 + 2as \tag{7}$$

we can get:

$$a = \frac{V^2 - U^2}{2s} \tag{8}$$

by considering initial velocity zero, we have:

$$a = \frac{V^2}{2s} \tag{9}$$

And we can get:

$$E = \frac{1}{2} m V^2 \tag{10}$$

The rate of changing energy can lead us to the power in the wind

$$p = \frac{dE}{dt} = \frac{1}{2} V^2 \frac{dm}{dt} \tag{11}$$

We know $\frac{dx}{dt} = V$, so the mass flow rate can be given by:

$$\frac{dm}{dt} = \rho A \frac{dx}{dt} \tag{12}$$

From equation 1, we can define power as:

$$P = \frac{1}{2} \rho A V^3 \tag{13}$$

Based on Bets limit (German physicist Albert Beltz), the maximum power efficiency energy in a wind turbine is 16/27 or 59.3%, and we can set C_p as:

$$C_p = 0.59$$

but in the real world, the power efficiency is around 0.35 - 0.45. Interestingly, the extractable power is defined as:

$$P_{avail} = \frac{1}{2} \rho A V^3 C_p \tag{14}$$

Solar Energy

Solar energy comes from the sun; solar radiation can produce solar electricity. These days there is a growing interest in using solar energy in underfloor heating systems. Solar collectors absorb the radiation from the sun and transform it to heat via a transfer medium. Two prevalent collector formats are Flat Plate Collector (FPC) and Evacuated Tube Collector (ETC). The average power density of solar radiation just outside the atmosphere of the earth is 1366 W/m^2, which is known the solar constant. The radius of the earth is (2/π) $\times 10^7$, so the total power of solar radiation reaching in the earth is:

$$1366 \times \frac{4}{\pi} \times 10^{14} \cong 1.73 \times 10^{17} W \tag{15}$$

With simple calculation, we can understand that the total annual solar energy reaching earth is $365.2422 \times 86400 \times 1.73 \times 10^{17} = 5.46 \times 10^{24} or 5,460,000 EJ / year$ $5.46 \times 10^{24} J$. Below we can see mathematical calculation.each year has 365.2422 days each day has 86400 seconds ($60 \times 60 \times 24 = 86400 s$)

$$365.2422 \times 86400 \times 1.73 \times 10^{17} = 5.46 \times 10^{24} \text{ or } 5460000 \text{ EJ per Year}$$

For a better understanding of this number, we can compare it with the annual global energy consumption in Figure 3. As can be seen, the energy consumed between 2005-2010 was about 500 EJ, which is one percent of the total solar energy reaching the earth.

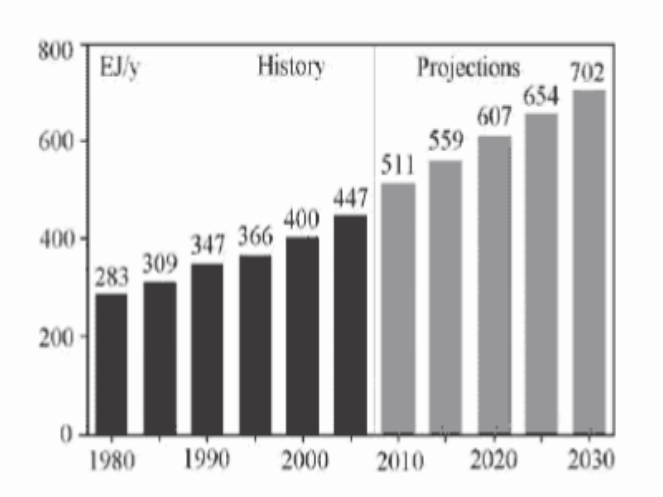

Figure3: Energy Consumption

Photovoltaic

Photovoltaic(PV) is the best way to turn solar radiation into electricity which was first observed by Henry Becquerel in 1839. Two electrodes, when attached to solid or liquid produce electric voltage. The photovoltaic device is also known as a solar cell. The solar cells are connected in series for two reasons. The first reason is that a series protects a solar panel from ambient the second is that a series it can deliver higher voltage than a single solar cell.Today, the range of efficiency is between 13% and 16% which is really low and need works to be improved. Using solar cells is very popular these days; some of the benefits are as follows:

- ✓ Direct conversion of solar radiation into electricity
- ✓ No mechanical moving parts, noise, or high temperatures
- ✓ No pollution
- ✓ A very long lifetime
- ✓ The ubiquitous, and inexhaustible source of energy, the sun
- ✓ A flexible energy source, its power ranging from microwatts to megawatts.

Hydropower

Getting energy from water is called hydropower. Since water is approximately 784 times denser than air (density of air near the sea= 1.275 $\frac{Kg}{M^3}$ and density of water is 1000 $\frac{Kg}{M^3}$), even a slow stream of water can lead to a considerable amount of energy. There are different ways to use water to produce energy such as deflecting water into the artificial channels[6] and using mill-ponds and water wheels.

A. Hydroelectricity

Converting hydropower to electricity is called hydroelectricity. Hydropower can be produced if the water supply is assumed, as with a river or mountain. In Norway today, hydroelectricity provides 98.5% of the electricity that country is using. It should be mentioned that hydroelectricity is a very useful way to avoid flooding. There are two types of hydroelectric plant: a run-of-river hydroelectric plant and a reservoir hydroelectricity plant.

There are two categories of a run of river hydroelectric plant: without and with pond. In the case of a run-of-river with no pond, the running water can rotate the turbine and the amount of water depends on the state of the river. This is also called hydrokinetic power, which is a type of hydroelectricity that can produce a lot of energy in rainy seasons or areas. The run-of-river with a pond has more advantages over the other one because the pond can provide enough capacity to increase generation to a maximum in a turbine. Overnight, the plant can refill the pond by decreasing the amount of electricity consumed. Figure 4 shows the hydroelectricity plant.

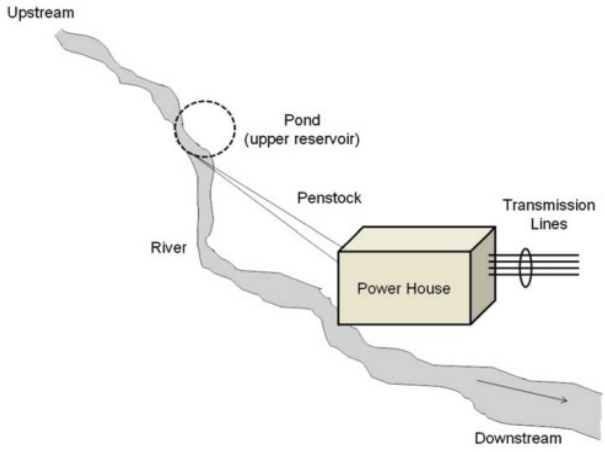

Figure 4: Run of River Hydroelectricity Power.

B. Reservoir Hydroelectricity Plant

In this type of hydroelectric plant, a reservoir is in a highland region or upland. The tank can store a large amount of water, so there is a potential for energy throughout the year. The reservoir can accumulate water

in the rainy seasons and use it in dry ones. The tunnel conducts the water from the reservoir to the turbine, and the water flow is controlled by the gate. most of the large hydroelectricity used around the world comes from this type of plant. At the peak time, the water delivery from a single tunnel to the turbine, and the station sends the power to the national grid. During low demand time, in the low demand time, the remaining water will be pumped to the tank again pumps. Figure 5 indicates the reservoir hydroelectricity power plant.

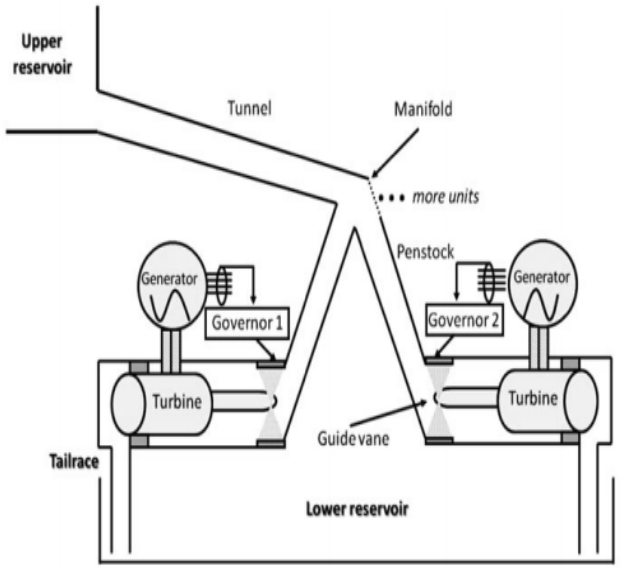

Figure 5: Reservoir Hydroelectricity Power Plant.

Geothermal Energy

The geothermal word originally comes from a Greek root, "geo meaning earth and thermal meaning heat. the heat comes from deep beneath the surface of the earth and we can use it to generate electricity. Geothermal energy is usually divided into two different categories: if the total heat content of the system is more than 302°F(150°C), it will be used to generate electricity, and if the total heat content of the system is less than 302°F(150°C), it will be used for direct heat.
the geothermal energy has positive features which make it competitive, the EU-Blue Book in Geothermal Resource claims:

- ✓ It is a local energy source that can reduce demand for imported fossil fuels.
- ✓ -It has a large positive impact on the environment by displacing combustion of fossil fuels.
- ✓ It is efficient and competitive with conventional sources of energy.
- ✓ Geothermal plants can operate continuously, without constraints imposed by weather condition, unlike other renewable sources.
- ✓ It has an inherent storage capability and is best suited to base-load demand.
- ✓ it is a reliable and safe energy source which does not require storage or transportation of fuels.

A. Hot Dry Rock Geothermal Energy

In 1970, Los Alamos National Laboratory proposed to extract heat of the area of the earth`s crust which contains no liquid. The hot dry rock geothermal energy (HDR) is different from hydrothermal energy. in hydrothermal energy, the hot water from the earth`s crust is employed to generate electricity but in the HDR system, the earth`s heat is used via closed loop circulation. We can use HDR system in every place, unlike the hydrothermal energy. As can be seen in Figure 6, firstly, by drilling a deep hole in the earth they inject the cold water beside the hole and pump the cold water inside the earth.consequently, the hot water will pump to the surface through the hole, so they use hot water to generate electricity.

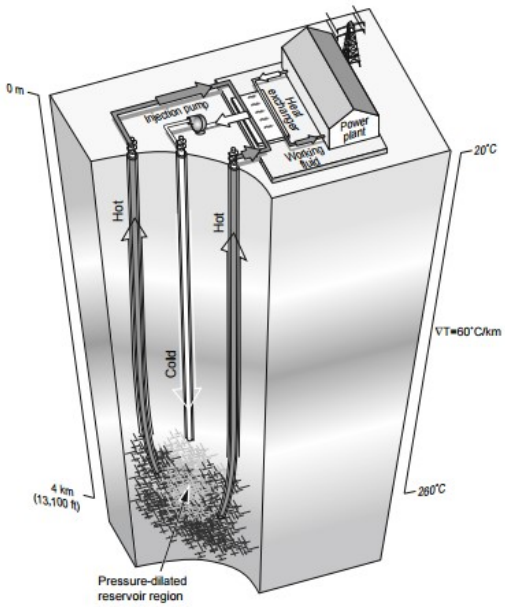

Figure 6: HDR System

Bio Energy

One of the most important sources of energy for transportation is biomass. Some of the organic materials can store sunlight and convert it to chemical energy; for example, the agriculture crops and municipal waste can store and convert sunlight. These days we can see in the gas station the fuel comes with ethanol. We can produce

ethanol from corn and obviously, the ethanol is less harmful compared to gasoline. In addition, the corn can be planted locally and prevent us from importing crude oil from other countries. We can generate electricity, heat or fuel transportation depend upon the biomass resource. We have three different kinds of biomass source: primary, secondary and tertiary. primary can be produced directly from photosynthesis. As Figure 7 indicates we can have a different type of energy through biomass; for example, biofuel can be produced from oil crops or the electricity from wet biomass.

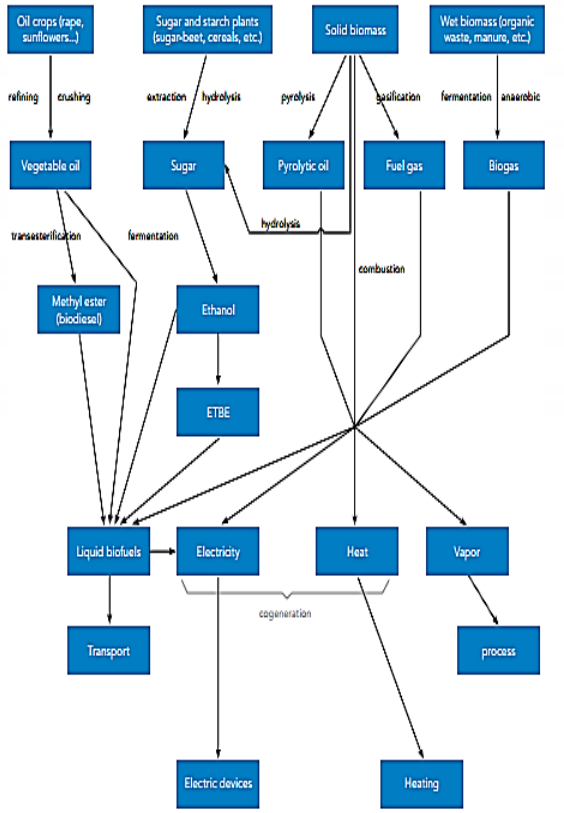

Figure 7: Bio Energy

III. CONCLUSION

In this research paper, we introduced the concept of renewable energy and explained different type of renewable energy resources and technology. According to the previous researches, doubling the share of renewables in the final global energy mix will raise Gross Domestic Product (GDP) in 2030 between 0.6 % and 1.1% compared to business as usual. Almasifard and Khorasani (2017) argued that only those countries with a certain long-term plan regarding their socioeconomic goals can succeed in this action [1,30]. It can be argued that any specific plans considered by policy makers regarding investment in the energy sectors and infrastructures can influence individuals' lives over following decades and change their daily purchasing power. These specific plans systems can have direct or indirect influences on the financial development of the country. Saeeidi (2017) argued that different levels of financial development change individual's choices regarding the level of their saving and consumption which can influence their purchasing power in the future [2].

As mentioned before, renewable energies are related to the geographical condition. We can get acceptable voltage from a wind turbine in the windy region and also, we can have useful solar energy in a sunny area. so, the first parameter that we need to consider for using renewable energy is an environmental condition. In addition, issues concerning greenhouse gases a developed country to invest more in renewable energy to avoid a global energy crisis.

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